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CHEMISTRY.—*Some problems in attaining adequate nutrition.*¹

PAUL E. HOWE, U. S. Bureau of Animal Industry.

In observing the problems that arise in the feeding of large groups of men in the Army and in charitable and penal institutions, and contrasting these problems with those that are encountered in the feeding of farm animals, I have been impressed with the extent to which man's aesthetic reactions to foods handicap his nutritional status. Much of the malnutrition that exists both inside and outside of institutions, as well as the unrest, discontent, and low morale that lead to demonstrations, riots, and other disciplinary problems, is the result of man's unwillingness or inability to base the satisfaction of his appetite on his dietary needs and on the restriction of his purse.

Nutritional workers have calculated the needs of both men and farm animals and have determined by analyses which of the available food products contain the essential elements in forms suitable for use.

In farm animals the nutritional problem is fairly simple. Scientific investigators have drawn definite conclusions as the result of laboratory work with animals and feeds and have made definite recommendations. Feeds for animals are evaluated scientifically on the basis of their nutritional and economic factors. On such a basis farmers are able to work out feeding schedules for their livestock in a sound and economical manner. It would seem equally feasible and highly desirable to approach human nutritional problems in the same objective manner.

Man, however, uses food as a means of satisfying many emotional needs, which are so closely tied up with his physiological needs that unless they too are met he fails to get the most from his food. He enjoys and even demands variety, not only in foods themselves but in methods of preparing them. He wants foods that appeal to his eyes and his senses of taste and smell; he wants to eat in pleasant surroundings. Traditionally, partaking of food with other persons has been of such social importance that the emotional satisfaction derived from eating has often overshadowed the actual physiological

¹ Address of the retiring president of the Washington Academy of Sciences, delivered on January 19, 1939. Received July 8, 1939.

needs supplied by food. These factors greatly complicate the attainment of an adequate diet.

No really comprehensive treatment of nutrition is possible in the limited time available. Therefore, I have selected for discussion certain phases of human dietary habits and some of the possibilities and complications that arise in the practical application of our knowledge of foods and nutrition.

COMPLICATIONS IN HUMAN NUTRITION

Man's fundamental nutritive requirements, as determined experimentally, are usually expressed in terms of chemical compounds or complexes—proteins, fats, carbohydrates, etc.—of the foods commonly included in his diet. Until recently these compounds making up the major parts of the diet were the chief consideration. The importance of the vitamins and certain of the mineral elements required in small amounts is now being recognized. Some of these compounds are known only by the effects produced in the organism when they are absent from the diet.

The necessary quantities of the various foodstuffs vary with the size, age, and activity of the individual concerned and with the external conditions to which he is subjected.

The requirements for the various nutrients are seldom considered by man when arranging his diet. Instead, he thinks in terms of food—meat, potatoes, milk, salads. As the science of nutrition has progressed, it has been necessary to reevaluate foods as sources of the various nutrients and to indicate the uses of particular classes of foods in the diet. To make the best use of available foods in meeting the variety of tastes and habits in man, it is necessary to know the composition of foods, the variations in the composition of the same food, and changes that occur between harvesting and consumption. Furthermore, variations occur in the composition of different varieties of the same product and also as the result of maturity, climatic conditions, the fertility of the soil, and other factors.

The preservation and purification of foods add further complications. Natural foods contain some of almost all the necessary nutritive factors, although the quantities present may be so small that the food can not be considered an important source of that particular factor. The methods of preservation and purification used to keep foods from spoiling or losing quality or to make them more attractive often change the composition of the original food. Thus, there may be a reduction in certain constituents on drying or cooking, or a concentra-

tion of nutrients such as occurs in the manufacture of white flour, refined sugar, and polished rice. These changes create special nutritional problems when products of this type form the major part of a diet. The use of polished rice is a good example. In polishing rice the outer hull and the germ, which contain vitamin B₁, are removed, leaving the inner starch-rich endosperm. People who live largely on polished rice develop the nutritional deficiency disease known as beriberi. This can be corrected by feeding the rice polish itself or some other source of vitamin B₁. Once polished rice has been used it is very difficult to get people to accept unpolished or brown rice, in spite of its superior nutritive value. The use of refined products, however, is not objectionable in itself, but it necessitates careful selection of other foods if the diet is to be adequate.

To meet the various food habits and tastes of a cosmopolitan population it is important to popularize more than one source of each nutritive factor. Fluid milk, for example, is the standard source of calcium. The daily consumption of a quart of milk by a child or a pint by an adult is an assurance of an adequate calcium intake. But those who do not like or can not get fluid milk may substitute canned or dried milk, cheese, an extra amount of leafy vegetables, or even calcium salts and still meet their daily calcium requirements.

Carotene, one of the precursors of vitamin A, is chiefly responsible for the yellow color of vegetables and milk. Carotene is also present in the green leaves of plants, although masked by the green color. Any of the yellow or green vegetables, especially the leafy vegetables, or the yellow foods derived from animals, may be selected as a probable source of vitamin A.

An example of the value of substituting one food for another for economic reasons was shown some years ago by Dr. A. F. Hess. At a time when lime juice and lemon juice were the accepted sources of vitamin C, the antiscorbutic vitamin, Hess demonstrated the value of tomato and potato juice for treatment of scurvy in Negro children in New York. In this way he introduced antiscorbutic foods that were cheap and easily obtainable.

SIMPLIFYING SELECTION BY USE OF FOOD GROUPS

To simplify selection, foods that are somewhat similar in composition or are particularly valuable as a source of one or more nutrients may be grouped together. For example, meats, milk, and eggs are sources of protein of good quality; milk, the leafy vegetables, and dried legumes are sources of calcium; the green and yellow vegetables and

butter fat are sources of vitamin A and carotene; fruits and vegetables, especially the acid products, are sources of ascorbic acid; and lean meat, milk, and the leafy vegetables are sources of nicotinic acid, the antipellagra vitamin.

By using such knowledge, it is possible to express the nutritive requirements in terms of the quantities of the various types of foods for an adequate diet. A classified dietary of this kind has been used rather successfully as the basis of dietary control in the Federal penal institutions. An example is given in Table 1.

TABLE 1.—STANDARD RATION FOR FEDERAL PENAL INSTITUTIONS
(Expressed in pounds per man per day)

Food groups	Type food	General messes	Hospital messes
Meats.....	Beef.	.75	.50
Fats.....	Oleomargarine.	.15	.15
Flour, etc. } Spaghetti, macaroni, rice, etc. }	Flour, white.	.80	.80
Dairy products.....	Milk, fresh. ¹	1.00	2.00
Eggs.....	Eggs.	.03	.25
Sugar and syrup.....	Sugar, granulated.	.25	.25
Beverages.....	Coffee.	.10	.10
Potatoes } Roots }	Potatoes.	1.00	.80
Leafy green and yellow vegetables } (including tomatoes 0.10 lb.) }	Cabbage. ²	.60	.50
Beans, dried, etc.....	Beans, navy.	.10	.10
Fruits, fresh or canned.....	Apples. ²	.15	.25
Fruits, dried.....	Prunes.	.08	.08
Miscellaneous.....	Yeast.	.015	.015
Spices, etc.....	Salt.	.10	.10

¹ In reporting evaporated milk, dried milk, and cheese, they are converted to their equivalents of fresh milk.

² When a greater quantity of some other food than the type food in this group is used in a given month, it becomes the type food for purposes of estimating the cost of the ration.

In this ration the foods are grouped according to one or more of the following characteristics: (1) Similarity of nutritive value, (2) palatability, and (3) dissatisfaction when too large quantities are used.

The use of food groups simplifies the recommendation of diets, offers considerable opportunity for variety of choice, and permits an approximate evaluation of diets from different parts of the country that reflect wide variations in food habits.

The monthly "Mess House Operations" report used by the United States Department of Justice for each Federal penal institution shows the total quantity and average daily consumption for each food group calculated to the pounds consumed per man per day. Other data related to the cost of the various items and waste are reported. A calculation is also made of the cost of such a ration based on the price paid

for the type foods, reporting each food group as indicated in the preceding table.

A report of this kind is very useful in appraising the nutritional value of the food consumed and the economy of the expenditure for food in an institution. Such an analysis, combined with an examination of the menus, indicates the probable acceptability of the foods served, as well as the adequacy of the diet. A knowledge of the skill with which food is prepared and served in an institution is necessary for a complete understanding of the satisfaction derived from its operations. It is interesting to note that various institutions show individual food patterns characteristic of the region in which they are located. Furthermore, it is often possible to detect a change in stewards or in administrative control by shifts in the quantities of different foods used.

Reports of the kind just outlined should be as much a part of the records of all public institutions responsible for the care of men, women, or children as the financial reports. In fact, the justification for the expenditure of money in institutions, armies, or navies is to provide an adequate satisfactory diet. Without records of foods consumed, it is impossible to demonstrate the extent to which the expenditures have been properly made.

Dr. Hazel Stiebelling, of the Bureau of Home Economics of the United States Department of Agriculture, has successfully employed food groups in setting up dietary standards for persons of different ages and sexes at various levels of income or satisfaction.

USE OF THE MENU OR MEAL PLAN

When selecting or planning meals and reviewing dietaries, it is possible to use certain devices to test the adequacy of the diet or its probable acceptability, such as (1) by the quantities of each of the types or classes required, which has just been discussed, and (2) by a series of meal plans or menus. In reviewing dietaries, both kinds of information are needed if an indication of the probable acceptance of the diet is desired.

A menu may be considered as a plan by which foods are combined to make a satisfactory meal. By working out a series of menus a variety of foods and an adequate diet can be assured. Menus tend to follow patterns and are part of our food habits. Through the skillful planning of combinations of food, nutritive elements in which the diet was previously deficient may be added often without upsetting an accustomed routine. A large part of the success of this method of

changing food habits lies in maintaining interest in the meals from day to day. This is just as true for maintaining good dietary habits as for changing poor ones.

Although the immediate concern will be with the proper nutritive elements in the menu, many other factors enter into the contentment and satisfaction people obtain from meals, particularly the methods of service and the surroundings in which food is eaten. Interest in food through the menu or meal plan is attained by (1) the use of foods attractive in themselves, (2) changes in methods of preparation of foods, and (3) combinations of the foods into attractively prepared dishes. In the last-mentioned case the attractive characteristics of some foods, such as meats, sugars, etc., may be used to add interest to less attractive but necessary or useful foods such as the bland cereal grains or vegetables.

It is not enough to provide variety among the meals of one day. It is necessary also to prevent the monotony that follows the frequent repetition of foods or combination of foods, or the repetition of the same foods at regular intervals. This is evident from the difficulties that arise in feeding large groups of persons such as in college dining halls, army messes, and correctional institutions, particularly when the cooking is mediocre. Poor cooking and monotonous meals have been responsible for many riots. It is a matter of record that Harvard College was almost wrecked in its early days because of monotonous and inadequate meals.

The meal plan offers a very useful method of selecting a meal from a restaurant menu or cafeteria counter. For example, in selecting a dinner one might soliloquize as follows:

"Soup? A small portion, it's appetizing and not too filling.

"Meat? Yes, a steak—no animal protein so far today.

"Potatoes? Yes.

"Other vegetables? Broccoli, turnips, beets, or carrots? Make it broccoli and carrots, not enough vitamin A so far.

"Salad? Lettuce or fruit? Lettuce with Roquefort dressing—more carotene and more calcium.

"Dessert? Cottage pudding? No, calcium is still low, make it pumpkin pie, and a cup of coffee.

"Now, let's see, I had grapefruit this morning, tomato juice this noon, and broccoli, carrots, butter, and salad tonight to provide sufficient vitamins C and A. The meat, bread, my peanut-butter sandwich this noon, and cheese provide plenty of protein. The calcium may be a little low but the cheese and pumpkin pie have helped, and there was skim milk in the bread.

"The B factors? I have had only white bread, but there were meat, peanut butter, cheese, and vegetables to help out.

"There is plenty of iron, and by the time I fill up on bread and butter there will be enough calories."

The chances are, however, that someone else plans the meals that you eat and enjoy without questioning whether all the necessary nutrients have been supplied. Even the housewife may use ready-prepared menus. What training did the person who planned the meals have? How well was the planning done? If a pattern was followed, was the pattern good? Upon the housewife, dietitian, cook, or steward often rests the responsibility for inducing us to eat foods that are needed even though we may not like them. They should be trained at least in the general facts of nutrition and the possibilities of changing food habits. We look to them to plan meals that we can enjoy with the assurance that they are adequate as well as appetizing.

Although menus and meal plans are useful in attaining a good diet, they alone do not provide sufficient evidence by which to judge adequacy. Often diets appear inadequate when judged by the menus but are shown to be adequate by analyses of the quantities of foods consumed. Conversely, a similar analysis of interesting-looking menus may show an insufficient intake of important foods, especially vegetables.

PSYCHOLOGICAL RESPONSES INFLUENCING ACCEPTANCE OF FOODS

I have so far discussed food requirements and methods of checking the adequacy of diets and have touched only lightly upon attitudes toward food and the difficulties that sometimes interfere with the attainment of an adequate diet. Although there are complications, they arise because of man's intelligence. In modern civilization many people have gradually conditioned themselves to expect and even demand a much more complicated dietary than is needed to satisfy nutritional needs. This enjoyment is one of the privileges of man. Insofar as people can afford these habits, they should enjoy them. Enjoyment is, however, only relative. New opportunities arise and with them new desires are created. On the other hand, when enjoyment interferes with the acceptance of an adequate dietary, the individual is faced with the dilemma of continuing his habits or accepting something that appears to him to be less interesting and satisfying. These changes are more easily accepted by the individual than by groups of individuals.

Man likes what he is used to, but he also likes a change. On this premise it should be possible, under circumstances in which he is faced with the need for a correction in the dietary, to condition himself to a new set of habits.

In any attempt to improve the nutritional status of a person, there-

fore, use should be made of instincts, appetites, habits, and any other devices to condition him favorably to desirable food habits. Hunger and appetite can be made valuable aids in securing the acceptance of food. Hunger that is due to actual contractions of the stomach stimulates the seeking of food. Appetite, on the other hand, is associated with the presence, or even the memory, of pleasant odors and flavors of food and may occur when the stomach is full. When hunger contractions or pangs occur, people show irritability and restlessness, even when the attention is so occupied that the contractions are not recognized. When three meals a day are eaten at regular hours, hunger contractions are seldom noticed, and when only one or two meals a day are eaten a certain amount of indifference to them may be built up. Excitement, pain, or anger inhibits hunger; outdoor exercise, physical work, or insufficient food stimulates hunger and lowers the level of discrimination, thus creating a situation favorable to the acceptance of new foods, that may be utilized when there is need to change dietary habits.

As a matter of fact, people often take food as the result of appetite rather than of hunger. Appetite stimulates the flow of digestive juices but is not essential to the digestion of food, since once in the stomach, food is equally well digested whether liked or not, provided no serious or continuous emotional factors are involved.

Habit plays an important role in the acceptance, as well as refusal, of certain foods and is thus useful in efforts to provide an adequate dietary. Habits are paradoxes. A man will eat the same breakfast year in and year out but will rebel if his dinners or suppers are the same or even if they are repeated at weekly intervals. In New England hot baked beans are traditionally necessary for Saturday suppers and cold baked beans for Sunday breakfasts. In the South boiled beans are or were often a customary second dish for both dinner and supper, but in other parts of the country if beans are served two meals in succession there is likely to be trouble.

Man is not alone in the persistence of habit in the face of change. Animals accustomed to a particular ration do not readily change to another unfamiliar diet. For instance, a farmer in Ohio purchased some cattle raised in North Dakota that had never been fed corn, and it took some time to teach these cattle to eat corn. He reports that one steer never did acquire the habit of eating corn. Animals, however, show a greater willingness to consume the food presented to them than does man. They can also be taught to expect variety in their diets. These habits usually result from the tutelage of man and are

frequently seen in household pets, where their owners have projected their own conceptions of the pet's desire for variety or for particular foods.

Conditioning is another device that can be used to modify food habits. The classic experiment of Pavlov's dogs has led us to see how many of our actions, including attitudes toward food, are the result of conditioning or involuntary reactions to stimuli. Poffenberger favorably conditioned a group of students to music they did not like by playing it while they ate attractive meals. Most of us can explain an intense aversion to a particular food by its association with some painful event, or remember discovering that we "liked" a new food when it was eaten on a gala occasion. Conscious use of such methods of modifying established habits or creating acceptance of desirable foods offers a valuable means of improving dietary habits.

The role of instinct in determining the choice of foods is not certain, but some interesting examples of its effect on choice are reported. The new-born animal, born with a strong sucking instinct, having once found the nipple, soon learns to return to it with unerring accuracy. As it grows older it samples the various objects within its reach, learns that some foods are better than others, and builds up a standard of selection within the limits of food available.

An experiment with rats, conducted for the purpose of determining whether animals search for specific nutrients, indicated that the choice of a particular food was the result of a generalized search for food and that habit or conditioning played a part in its selection. Under experimental conditions rats have been found to choose a satisfactory diet from 11 relatively pure foods, including protein, carbohydrates, fat, certain vitamin-rich foods, and minerals, and to increase the consumption of sodium chloride or calcium where additional quantities of these elements were needed. Experiments with chicks showed that some of them consistently chose better diets than others.

Man's instinct or ability to select a satisfactory diet from among a number of foods or to modify the diet to meet changes in nutritive requirements has also been demonstrated. There is a careful report of three young children who were allowed complete freedom of choice from among a wide variety of natural foods over a long period of time. The diets selected met all their nutritive requirements and resulted in excellent growth. Normally, however, man's instinct is so overlaid by conditioning that he can not be trusted to select food with any relation to his physiological needs.

At present, sufficient evidence to determine the exact manner in

which the body recognizes nutritional deficiencies and determines the choice of food is lacking. One suggestion is that nutritional deficits cause physiological changes in the body and that these changes alter the taste mechanism and set up a craving for a specific food.

These nutritional facts and the attitudes of man to food may well serve as the basis for considering a problem that frequently defeats efforts to improve the nutritional status by setting up dietary standards. A survey of dietary habits indicates that there is still much to be done in bringing people to accept a diet that meets the caloric needs of the body and provides a liberal allowance of all the nutrients required. It is concerned with the maintenance of morale in men fed in groups, as in the Army and Navy, and the practical application of the newer knowledge of nutrition to the improvement of our national health and economic welfare. The difficulties involved become evident when an attempt is made to change the food habits of persons satisfied with a generous but nutritionally inadequate diet, to make drastic changes in the food of troops and yet maintain their morale, to set up a restricted though adequate diet for persons on relief, or even to understand the problems of the housewife who tries to stay within her food budget and still have a well-nourished and satisfied family. In each case the major problem lies in getting the persons concerned to accept the foods that should be used among those that are available.

Evidence has just been presented that indicates that young children and animals will select a fairly adequate diet if given a reasonable variety of natural foods from which to choose, or that they will seek other foods if the diet presented is inadequate. But as man grows older and develops fixed habits this faculty of selection of the diet is apparently submerged and seldom used. The desire for palatable or customary foods displaces the urge to search for foods that will make the diet more satisfactory from a nutritional standpoint.

VALUE OF EDUCATION AND TRAINING

The most promising solution of the problem of getting people to accept an available adequate diet lies in education and training. Training must begin with the establishment of good food habits in the child and involves learning to enjoy a simple adequate diet and to be willing to accept new foods to replace or supplement customary foods. The success of this program depends largely upon skill and attitude of the mother. Although education begins at home, it should be carried on also in the schools. Information given there reaches back into the home and affects the parents and other members of the family. Fi-

nally, there are great possibilities for general education for better dietary habits, particularly for adults. Here the problem is to insure the sound, broad presentation of facts, unbiased and in their proper relationships. Many books, bulletins, and pamphlets containing a large amount of information about nutrition are available for use in the home and school. Radio broadcasts and household publications offer advice and aid in planning meals. Many of these are biased; hence the information should be carefully evaluated before it is accepted. Great care must be taken to make sure that material to be used in the schools is factually accurate, that it presents completely unbiased discussions, and that it promotes no food product exclusively. Sometimes material is offered as educational that is really special pleading for particular food products. It may be well written, accurate, and informative. While manufacturers and industries are justified in advertising the merits of their products, this promotional material usually lacks the detachment and broad approach that should characterize educational material and should not be confused with it.

A considerable part of current popular material about food is presented in the form of recipes. This kind of material is very useful in securing the acceptance of new foods or the wider use of common foods. While recipes may be of little immediate interest to students of nutrition they are of real value to those who must prepare and serve meals. Since these persons should always consider foods in relation to their nutritive values and their place in the diet, material on preparation should present facts about the place of the foods in the dietary. An example of an excellent service of this kind is the weekly mimeographed press release called "The Market Basket," which the Department of Agriculture has issued for a long time. It has combined information on the general nutritive requirements of the family with information on seasonable foods and presents simple yet attractive methods of preparation.

As previously pointed out, material that is to be used as a guide either in teaching nutrition or in planning dietaries should suggest more than one major source of each of the nutrients. This is especially true if the material is to be used by people in all parts of the country and if people are to be taught the possibilities of varied diets.

The average person can hardly expect to keep well informed about all the changes in and additions to knowledge of man's food requirements, but he should realize the extent to which his food habits play a part in determining his well being. He should also realize that these are not infallible guides and that a nutritionally abundant and rea-

sonably satisfactory diet can be achieved at different income levels if one is willing to bring an open mind to its acceptance. If the housewife, steward, or cook can combine this knowledge with skill in the selection and preparation of food, real progress toward better nutrition can be made. Thus man can satisfy his body requirements for food without losing the opportunities to enjoy it.

BIOPHYSICS.—*Delayed killing of maize seeds x-rayed at liquid-air temperature.*¹ LOUIS R. MAXWELL, U. S. Bureau of Agricultural Chemistry and Engineering, and J. H. KEMPTEN, U. S. Bureau of Plant Industry.

The first stage in the biological response to x-rays is the absorption of quanta with the production of high-energy primary electrons. As these particles traverse the medium they lose their energy in the process of ion pair formation. On the average as each ion pair is formed there will be about 32 electron volts of energy taken from the primary electron. These early physical phenomena will be independent of temperature changes and will always provide discrete amounts of energy to the medium. The ion pairs formed will react with neighboring molecules and, since their energy is large compared with ordinary thermal reactions, these processes should not be dependent on temperature. These ionic reactions will then provide the initial energies of activation for subsequent low-energy, including thermal, reactions. The subsequent changes will be manifested by changes in the living plant. It is to be expected that many of these low-energy reactions will depend upon temperature changes. Any external influences, such as extreme variations of temperature, that will greatly affect any of these fundamental steps should prove to be a useful tool in the investigation of biological response to radiation with x-rays.

Maintaining the specimens at about -187°C . by means of liquid air during irradiation should largely eliminate significant thermal reactions within the material. The subsequent development of such specimens under normal growing conditions should give information as to the actual importance of thermal reactions during the time of irradiation. In the present experiments dry maize seeds were used because they are able to withstand submergence in liquid air without seriously altering their subsequent growth (9).²

Various experimenters have investigated the effects of small changes of temperature during the time of irradiation by x-rays. Early work

¹ Received May 24, 1939.

² Numbers in parentheses refer to the "Literature Cited."